|  |
| --- |
| THIS DOCUMENT HAS BEEN PREPARED FOR THE PURPOSES OF THE  **PROJECT RESOURCE CENTER**.   IT IS FOR GENERAL GUIDANCE PURPOSES ONLY AND SHOULD NOT BE USED AS A SUBSTITUTE  FOR SPECIFIC TECHNICAL, PROCUREMENT OR LEGAL ADVICE FOR A PROJECT |

# Terms of Reference

**DETAILED ENERGY AUDIT FOR STREET LIGHTING**

## Background

*<Rationale for the project, energy sector and energy demand in the country, aims of the project, project components.>*

## Objective

The purpose of this assignment is to assess the EE potential in street lighting in the [municipalities], and to identify potential energy efficiency investments which may cover the rehabilitation and optimization of the lighting system, including lighting equipment replacement, and associated infrastructure (see section below on Scope) to enhance energy efficiency.

## Scope of Detailed Energy Audits

The detailed energy audit includes data collection, measurements of the systems, analysis of the historical and measured data, and detailed energy savings as well as financial and economic calculations for suggested street lighting projects. The detailed energy audit not only involves the analyses of the performance of individual equipment, but the evaluation of the complete system. The detailed energy audit includes the following key steps: (i) calculation and establishment of the energy consumption baseline; (ii) assessment of potential energy efficiency options and the identification and costing of recommended measures for reducing energy costs and improve energy efficiency in street lighting; and (iii) the monitoring and verification framework.

The detailed energy audits should cover the following elements: (i) lighting fixtures; (ii) poles; (iii) arms; (iv) electrical wiring; and (v) management and control systems for street lighting.

It is also important that the audits take into account the key features of effective energy-efficient street lighting systems which include (i) proper pole height and spacing; (ii) proper luminaire aesthetics; (iii) high lamp efficacy and luminaire efficiency; (iv) life of the luminaire and other components; (v) cost-effectiveness; (vi) high lumen maintenance; (vii) good color rendering; (viii) short lamp restrike; (ix) proper light distribution; (x) proper cutoff; (xi) minimizing light pollution; (xii) automatic shutoff; (xiii) compliance with national and local norms and standards for street lighting.

The Detailed Energy Consumption study should also include an assessment of the quality of the street lighting service and enable and assessment of the overall potential in terms of energy and cost savings, but also other potential benefits associated with more energy efficient lighting systems (e.g. lighting quality, impact on municipal operational budget, environmental benefits, safety/security, etc.).

The detailed energy audits will need to be conducted in close collaboration with the municipality and [partner]. Although some municipalities in [country] have some of their street lighting metered, metering of street lights is typically not comprehensive within a municipality. However, where such metering is in place, it should be taken into account in the process of conducting the detailed energy audits.

## Tasks

Working closely with the [municipality], the consultant will conduct detailed energy audits and prepare energy audit reports for street lighting in [2] municipalities.

It is also important that the audits take into account the key features of good quality street lighting which include reducing glare, providing sufficient illumination to ensure the safety of drivers and pedestrians, complying with relevant standards, ensuring color consistency, and cutting the amount of energy consumed.

The Consultant will be responsible for undertaking the following tasks:

Task 1: Review background information, data collection, site visit and definition of baseline and current (i.e., without project) context.

The consultant shall review of background information, as well as relevant guidance from [partners] and [survey]. This background information should be complemented by an infrastructure site visit to assess current infrastructure and operating conditions, map out the existing facility for street lighting and identify data collection points for the detail energy audit report. The site visit should be conducted jointly with the municipality’s street lighting expert.

Based on [the partner]’s methodology to establish electricity consumption baselines (i.e., electricity consumption without the implementation of energy efficiency project), the consultant will document the electricity consumption baseline for street lighting.

The consultant will also clarify the current (without project) context of the street lighting system, including the energy balance of the system (for each type of technology), electricity and O&M costs, inventory and quality of lighting equipment, as well issues related to current service levels (e.g. quality of light; consistency of light, lamp failures, coverage) and as compared to relevant national norms.

The Consultant shall review copies of invoices and bills of electricity consumption for street lighting for the past three years. Additional information on existing service levels, past upgrades, should also be provided as available. The Consultant will work with the Municipality to coordinate with relevant department(s) of the Municipality to facilitate the field visit.

The consultant should produce a brief interim report, for review by the [donors] and [partners], defining the approach and methodology (for electricity consumption as well as broader context) to determine the current baseline against which the performance of the energy efficient project will be assessed, as well as key parameters, including:

* Inventory of different types of lamps to be replaced, including their rated capacities, efficacy (lumens/Watt), lifetime (hours), lamp and fixture types, ballast capacity/type, etc.
* Description of the type of road as well as dimensions.
* Street light power consumption (Kwh per year)
* Average power consumption per light point
* Street light operation (hours per day/year)
* Energy and O&M costs per year; electricity use should be based on actual bills for the past 3 years along with any censuses conducted by CFE during this period
* Average illumination levels in each streets of the municipality (in lux)
* Density of electric power for lighting (DPEA) W/m2
* Compliance with street lighting national and local norms

The interim report should determine the current (baseline) energy O&M expenditures, greenhouse gas emissions, energy indicators (example provided in Annex 1), quality of service, and current context, such as light pollution, peak demand associated street lighting, security and safety, as well as, for example, street lighting-related expenses in the municipality’s operating budget, and include associated methodology and calculations in an Annex.

The data to be collected and reviewed will involve a mixture of spot measurements, metered data, energy bills, and other historical data.

In the interim report, the consultant should also specify the criteria/conditions and procedure to be followed for adjusting the baseline, in consultation with [partner]. Provide all the baseline parameters and the calculation procedure in an annex.

Output: Brief interim report that presents key findings from the site visit and establishment of electricity baseline against which the energy savings from proposed energy efficiency investments will be assessed, as well as outlines the methodology used, including data collection sheets for recording monthly energy consumption and operating data. All the baseline parameters and the calculation procedure should be included in an annex. The report should describe the overall baseline context for the lighting system of the municipality, as well as the conditions and procedure that would trigger an update of the baseline.

Task 2: Assessment and identification of cost effective measures for reducing energy cost and improve energy efficiency in street lighting

Based on the analysis of the baseline and assessment of current infrastructure and operations conditions from the field visit and information and data collected in task 1, the Consultant will consider and identify technically-viable EE measures/options and, for each one, calculate the investment needed, energy consumption and energy/O&M cost savings, simple payback period, net present value (6% discount rate), environmental and other benefits (as noted above).

For the assessment of EE potential, the consultant should consider all likely EE measures including: lamp replacement (with higher efficiency technology, such as LED and metal halide); replacement of fixtures (including replacement of ballasts, reflectors, etc.); redesign of system (including number, height and spacing of poles); control systems (e.g., dimmers), and other options as appropriate. The assessment should include the long-list of options considered, relevant cost and financial information for each, indicate which options were not considered for technical reasons, and include a separate summary table of options with positive NPVs. The financial analyses should also specify all assumptions used (electricity costs, electricity tariff, technology costs, equipment lifetime, hours of operation, grid emissions factor, inflation rate, etc.).

### Task 3: Development of Implementation Plan and MRV framework to assess performance of energy efficient street lighting project.

Considering the list in Annex 4, the consultant should propose indicators that will be the basis for monitoring results and the method of calculation for each one. The Consultant must also outline the method of monitoring the energy performance of lighting system, specify the data to be monitored and its processing, recording and the presentation of results.

The Consultant will outline a recommended implementation Plan for the identified energy efficiency measures, highlighting key tasks (including to sustain energy efficiency over time), timing and competencies required.

The Consultant shall clarify the criteria, variables, relevant regulations and methodology for the determination of all electrical parameters, and for each of the proposed EE measures, as well as define the key measurement points in the lighting system to be included in the MRV.

For the identified cost-effective energy efficiency measures, the consultant will prepare technical specifications for testing equipment and bidding documents.

The Consultant will also specify and outline the procedure for collection and safe final disposal of replaced lamps and mercury content. The estimated cost for the safely disposing of hazardous material should be included in the proposed recommendations.

The Consultant will also list and prepare a table for the measurements to be done before, during and after the implementation of the project (in order to monitor the performance of the energy efficiency measures and investments).

The methodology to determine the energy savings and energy indicators must be validated by [project partners].

The consultant should also determine the parameters, measurements and procedures to be used to assess overall performance of the energy efficient street lighting project (e.g., lighting quality, coverage, cost savings to the municipality, environmental benefits, impact on peak demand, safety/security, etc.).

Output: Draft of Detailed Energy Audit and PowerPoint presentation to get initial feedback.

Output: MRV Framework (including parameters, measurements and procedures necessary for the assessment of energy saving and impact of each proposed energy efficiency measure, as well as indicators).

### Task 4: Preparation of final Detailed Energy Audit Report

The table below provides an example of the structure and key elements of a street lighting audit report.

|  |  |
| --- | --- |
| **Contents** | **Description** |
| Executive summary | Provides a brief description of the systems and facilities covered; overview of the existing conditions; measures evaluated; analysis methodology; results and a summary table presenting the cost and energy savings estimates for each recommended measure. It also includes a summary of the recommended measures and costs, as well as the financial and energy indicators of the projects, and indicators to measure other impacts of the project (quality of service, impact on municipality’s budget, mercury content, greenhouse gas impact, etc.) |
| Background | Extensive background about the municipality and project should be provided. Include information on municipality’s budget and expenditures for street lighting. |
| Facility description | Details of existing facilities targeted, such as street lighting, poles, and electrical distribution systems. Compliance with relevant norms. (See also Annex 3 for example of data to be presented). |
| Energy scenario | Electricity consumption details of all the facilities.  Specify grid emissions factor associated with electricity consumption. |
| Inventories | Inventories of all relevant systems, related to public lighting. |
| Baseline parameters and adjustments and description of current lighting context | Electricity consumption baseline and its parameters, as well as methodology. Provide all baseline parameters and calculation procedure in an Annex.  Description of the criteria/procedure to trigger adjustments, along with steps to be followed for any baseline adjustments. |
| Description of baseline lighting service, baseline electricity and O&M costs, GHG emissions, etc. |
| Review of current operation & maintenance practices | Provide detailed description of current operation and maintenance (O&M) practices with the municipality facility, including hours of operation and use of meters and control systems, as well as dimming (as appropriate). This will include discussions with operators, engineers and other staff, observing the day-to-day O&M and reviewing the log sheet during the field study. |
| Data collection | Prepare data collection sheets (and guidance for data collection system) listing the various types of data collected and their sources, including on operational details of the lighting system. Include data in an Annex. |
| System mapping | Include available system mapping in an Annex (i.e. information on locations of street lights). |
| Potential measures/projects | A list of all identified measures with estimates of the investment cost, energy savings, cost savings, O&M savings, and payback on investment. |
| Details of proposed project | **PROPOSED Project**: provide background of the opportunity for improvements, and describe proposed measures. See Annex 2 for example of description of new lighting system. Discuss proposed retrofits and modifications necessary for achieving savings and associated cost benefit analysis.  Clarify compliance with relevant [country] norms and standards for performance, security, as well as photometry (for LEDs and metal halide). |
| **CALCULATIONS**: Energy savings and other calculations (include in an annex).  -Provide a detailed energy analysis for each energy saving measure proposed, documenting estimated annual energy savings. Document assumptions on current and proposed equipment operating condition and energy savings calculations.  -Greenhouse gas calculations  -Energy indicators  -Economic calculations on a life-cycle basis, including both energy and operation and maintenance costs and savings.  - Other measurable impacts (related to quality of lighting, budget situation of the municipality, environmental impacts, etc.) |
| -**Monitoring/measurement, Reporting and Verification (MRV):** Outline MRV plan for monitoring, verifying and guaranteeing energy savings from the implementation of the energy saving measure, including identification of monitoring equipment, availability, confidence interval, data collection procedure, etc. Outline also MRV plan to assess other aspects of the performance (e.g., energy and O&M savings, quality of lighting, greenhouse gas and other environmental impact, safety/security, etc.). Include templates to facilitate collection of information and tracking of performance. |
| -**IMPLEMENTATION PLAN and SCHEDULE**: Outline tasks and timeline for data collection, MRV framework implementation, assessment of energy balance, realization of energy savings, project contracting, as well as outline technical specifications and provide a proposed implementation schedule, including, for e.g., design completion, equipment/material acquisition, installation, start-up/testing, installation.  Outline procedure for safe collection and disposal of replaced lamps. Provide estimate of cost. |
| - **RISKS and their Mitigation**: Assessment of potential technical and financial risk and a risk mitigation plan (presented in a Risk Matrix[[1]](#footnote-1)), such as:   * Design and construction risks (e.g., Baseline establishment; Technical efficacy; Completion risk; Delay in construction; Compliance with standards and government approvals) * Performance risk (e.g., Equipment performance; accuracy of savings estimates; MRV risk; Operational changes; Capacity of personnel) * Financial, economic and regulatory risk (cost overrun – initial and operating; regulatory – changes in laws relating to tax concessions etc.; financing) * Market risk (energy price risk due for example to changes in tariffs) |

Each report must include all attachments and calculation sheets (Excel), corresponding analysis, surveying network, simulation models, existing and modified plans of the proposed equipment specifications assessed and proposed equipment, supply systems diagram, etc.

In producing the report, the Consultant should review relevant available documentation (e.g., plans of public lighting system, collection of equipment nameplate data, O&M manuals, specification data for major equipment, and performance data, energy bills[[2]](#footnote-2), etc.), as well as information on current infrastructure and operational conditions, including from the field visit, and relevant [country] norms.

Output: Detailed energy audit reports in [language], including methodology, data, context description, baselines assessments, identified measures with and economic and financial assessments, as well as other associated impacts (on quality of service, budget of municipality, and on greenhouse gas emissions), MRV plan.

## Expected qualifications and expertise

The Consultant is expected to have:

* Knowledge of federal legal procedures with the various agencies involved in the realization of the project as well as the necessary documentation for the contracting, e.g. minutes of council, Bill, permits, legal representation documents and outline legal.
* Familiarity with the operator’s monitoring and evaluation practices and street lighting systems’ energy performance (including in different roadways).
* Operator skills and capacity to follow up and evaluate contracts and bills.

The following expertise is sought:

1. Project Manager, Energy Efficiency Specialist with specific project management experience of 10+ years in EE assessments, energy audits, EE in street lighting.

The expert has been project manager of at least five related feasibility studies, EE assessments and energy audits of buildings. The expert has a university degree in engineering, energy economics or similar and solid experience in the development of feasibility study assessments of EE measures in street lighting and performance of energy audits. Experience in [country] is required.

1. Deputy Project Manager and EE Design Engineer.

Design/costing engineer with at least 7 years of experience. University degree in civil engineering or equivalent. Detailed and long term experience in Mexico in the field of energy efficiency and street lighting design and renovation, standards and norms for street lighting in accordance with legislation in [country] and detailed experience with costing. Fluency in [language] required.

1. Energy Audit and MRV Specialist.

The expert has a university degree in energy, engineering or similar with 10+ years international professional experience in the development of energy auditing, developing energy baselines, assessing EE measures, EE project commissioning, EE in street lighting, etc. Experience in [country] is an advantage.

1. Energy economist.

The expert has a university degree in environmental or energy economics or similar and at least 5 years of experience in preparation of feasibility study analysis, cash flow analysis, IRR/NPV/payback calculations of a variety of EE measures. Experience in valuing co-benefits of energy efficiency interventions would be an advantage.

## ANNEX 1 – Example of table for indicators for pre and post installation technology

|  |  |  |
| --- | --- | --- |
| **Parameters** | **Pre-installation** | **Post-installation** |
| Lighting Technology |  |  |
| Wattage (W) |  |  |
| Lumens (lm) |  |  |
| Efficacy (lumen/Watt) |  |  |
| Lifetime (years) |  |  |
| Illuminance (lux) |  |  |
| Colour rendering Index (CRI) |  |  |
| Street Name |  |  |
| Number of light points\* |  |  |
| Street dimensions |  |  |
| Operating hours (per year) |  |  |
| Electricity consumption per year (kWh) |  |  |

\*of the same technology located in the same street

## Annex 2 – Example of parameters of new lighting system

(a) Classification of the roads

(b) Specification for street lighting poles

(c) Recommended levels of illumination and Mounting Height of Luminaires

(d) Type of lamps

(e) Wattage of system (lamp + ballast)

(f) Illuminance (lux)

(g) Density of electric power for lighting (W/m2)

## Annex 3 – Example of data to be collected to document existing condition of lighting system

* Physical condition of existing street lighting system
* Description of metering and control system (as relevant)
* Number and locations of sub-stations in the municipality
* Details of power supplied for street lighting systems from each of the stations on a daily basis for the past 12 months
* Monthly electricity bills of the individual street lighting circuits for the past 12 months (as relevant)
* Number and type of lights changed over the past 3 years (as relevant)
* Number and locations of the street lighting transformers in the municipality
* Number of feeders and conductor sizes in each of the transformers
* Number and type of lights and fixtures in each of the feeder, including lux levels and color rendering index (CRI)
* Length of each feeder
* Height of poles
* Distance between poles
* Type of Lighting technology
* Potential power light points
* Operational hours
* Electricity cost (MXN/kWh) and tariff category
* Street lighting electricity cost per year (MXN/year)
* O&M street lighting costs per year (MXN/year).

## Annex 4 – Street lighting energy efficiency indicators

Note: energy indices or indicators of energy performance are a quantitative value or measure of the energy performance as defined by the company, industry or authority.

• Lighting power density [W/m²]

• Luminous efficacy [lm/W]

• Illumination level in luxes

• Avoided CO2 emissions per year [TCO2 / year]

1. Matrix would provide classification or type of risk; reason for the risk; risk mitigation measure adopted. [↑](#footnote-ref-1)
2. Monthly electricity bills should be reviewed. [↑](#footnote-ref-2)